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2 What is claimed is:

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- 5 1. A method for forming a photoresist pattern on a prescribed film, said photoresist
6 pattern having a multi-level profile formed from exposure to light transmitted through a
7 reticle having a multi-level profile, wherein the reticle includes one or more films
8 overlying the reticle substrate to partially transmit and shift the phase of incident light,
9 the reticle substrate passing all incident light and
10 the partially transmitting phase shift film transmitting approximately
11 20% to 70% of incident light and shifting the phase about 180 degrees in transmission
12 through the partially transmitting film, and
13 an opaque film overlying sections of the partially transmitting film, the
14 opaque film blocking light so that all incident light is attenuated,
15 the method comprising the steps of:
16
17 a) exposing a light sensitive photoresist film, having a predetermined
18 thickness, to light transmitted through the reticle for a predetermined amount of time, with
19 light being transmitted through the reticle substrate exposing a first photoresist area to a
20 first dosage,
21 with light being transmitted through the partially transmitting film
22 exposing a second photoresist area to a second, intermediate dosage, and
23 with light being transmitted through the remaining opaque film
24 exposing a third photoresist area to a third dosage; and
25
26 b) developing the photoresist substrate exposed in step (a) to form a
27 photoresist profile having an opening in the first photoresist area,

1 the photoresist profile having the photoresist predetermined thickness in
2 the third photoresist area, and the photoresist profile having an intermediate thickness,
3 between the predetermined thickness and zero, in the second photoresist area,
4 whereby light introduced to the reticle transmits at least three intensities
5 of light to transform the photoresist substrate into a profile of at least two thicknesses and
6 an opening.

7 2. The method of claim 1 wherein said light sensitive photoresist
8 film is comprised of a lower photoresist layer and an upper photoresist layer; said lower
9 photoresist layer is less sensitive to light than said upper photoresist layer.

10 3. The method of claim 1 wherein said light sensitive photoresist
11 film is comprised of a lower photoresist layer and an upper photoresist layer; said lower
12 photoresist layer is less sensitive to light than said upper photoresist layer between between
13 about 5 and 10%.

14 4. The method of claim 1 wherein said light sensitive photoresist
15 film is comprised of a lower photoresist layer and an upper photoresist layer; said lower
16 photoresist layer is less sensitive to light than said upper photoresist layer in a case where
17 the layers are positive type or
18 said lower photoresist layer is more sensitive to light than said upper
19 photoresist layer in a case where the photoresist layers are negative type.

20 5. The method of claim 1, which further includes etching in a single step, said
21 photoresist film and said a dielectric layer under said photoresist film to form a dual
22 damascene shaped opening in said dielectric layer;
23 said photoresist film and said dielectric layer have about the same etch
24 rate.

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- 1 6. A method of forming a photoresist profile on a substrate using a reticle having a
2 multi-level profile including
3 (1) a transparent substrate,
4 (2) a partially transmitting 180 degree phase shift film overlying
5 predetermined areas of the transparent substrate to transmit approximately 20 to 70% of
6 incident light, and
7 (3) an opaque film overlying the predetermined areas of the partially
8 transmitting 180 degree phase shift film,
9 the method comprising the following steps:
10 a) depositing a photoresist film having a predetermined thickness on the
11 substrate;
12 b) directing light to the photoresist film through the reticle, the reticle
13 transmitting a first intensity through the transparent substrate to create a first exposure
14 pattern,
15 the reticle transmitting a second intensity, less than the first intensity,
16 through the partially transmitting 180 degree phase shift film to create a second exposure
17 pattern, and
18 the reticle transmitting a third intensity, blocking about all incident
19 light, through the opaque film to create a third exposure pattern; and
20 c) developing the photoresist film to remove a first thickness of
21 photoresist film, approximately equal to the predetermined thickness, in areas of the first
22 exposure pattern, and
23 to remove a second, intermediate thickness of the photoresist film, less
24 than the first thickness, in the areas of the second exposure pattern, whereby the profile
25 includes areas of photoresist film having a plurality of different thicknesses.
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- 1 7. The method of claim 6 wherein said photoresist film is comprised of a lower
2 photoresist layer and an upper photoresist layer; said lower photoresist layer is less
3 sensitive to light than said upper photoresist layer.
- 4 8. The method of claim 6 wherein said photoresist film is comprised of a lower
5 photoresist layer and an upper photoresist layer; said lower photoresist layer is less
6 sensitive to light than said upper photoresist layer;
7 the sensitivity of the lower photoresist layer and the upper photoresist
8 layer is adjusted so that :
9 * the first intensity of light through the transparent substrate sensitizes
10 both the lower and upper photoresist layers; and
11 * the second intensity of light through the transparent substrate
12 sensitizes only the upper photoresist layer; and
13 * the third intensity of light through the opaque film does not sensitize
14 the lower or the upper photoresist layer.
- 15 9. The method of claim 6 wherein said photoresist film is comprised of a lower
16 photoresist layer and an upper photoresist layer; said lower photoresist layer is less
17 sensitive to light than said upper photoresist layer by between about 5 and 10%.
- 18 10. The method of claim 6 which further includes: said photoresist film is comprised
19 of a lower photoresist layer and an upper photoresist layer; said lower photoresist layer
20 is less sensitive to light than said upper photoresist layer; and
21 transferring said pattern in said photoresist film by an etch into the
22 surface of said substrate in a single etch step; the etch rate of said photoresist film and said
23 substrate are about equal.
- 24 11. The method of claim 6 wherein said substrate is an integrated circuit substrate.
25

- 1 12. A reticle through which at least three intensities of incident light are passed to
2 define a multi-level profile on a light sensitive photoresist surface, the reticle
3 comprising:
- 4 a) a first transmission level film producing transmitted light of a first intensity;
 - 5 b) a second transmission level film producing transmitted light of a second,
6 intermediate, intensity less than the first intensity, and retarding the phase of
7 the transmitted second intensity of light approximately 180 degrees; and
 - 8 c) a third transmission level film producing transmitted light of a third intensity
9 less than the second intensity, whereby the light transmitted through the reticle
10 with the first intensity exposes a first photoresist area to a first dosage, the light
11 transmitted with the second intensity exposes a second photoresist area to a
12 second dosage, and the light transmitted with the third intensity exposes a third
13 photoresist area to a third dosage.
- 14 13. The reticle as in claim 12 in which said first transmission level film is a substrate,
15 in which said second transmission film overlies said substrate, and in which said third
16 transmission level film overlies said second transmission level film.
- 17 14. The reticle as in claim 12 in which said third transmission level film is an opaque
18 film selected from a group consisting of Cr, CrO, and iron oxide, whereby said third
19 transmission level film blocks incident light.
- 20 15. The reticle as in claim 12 in which said first transmission level film is selected
21 from a group consisting of quartz, synthetic quartz, and glass, whereby said first
22 transmission level film is transparent to pass all incident light.
- 23 16. The reticle as in claim 12 in which said third transmission level film has a third
24 transmission level opening, through said third transmission level film, to reveal a
25 predetermined area of said second transmission level film, and in which said second

1 transmission level area has a second transmission level opening, through said second
2 transmission level, to reveal a predetermined area of said first transmission level film.
3

4 17. A reticle for transmitting at least three intensities of incident light to create a multi-
5 level profile pattern of at least three thicknesses on a light sensitive photoresist film
6 overlying an integrated circuit interlevel dielectric, the reticle comprising:

7 a transparent substrate, said transparent substrate passing all incident
8 light to form a first thickness of photoresist profile less than the first thickness of
9 photoresist film,
10

11 a partially transmitting film, said partially transmitting film retarding the
12 phase of incident light approximately 180 degrees and transmitting between approximately
13 20% and 70% of incident light to form a second thickness of photoresist profile; the
14 second thickness greater than the first thickness of photoresist film;
15

16 an opaque film, said opaque film blocking all incident light to form a
17 third thickness of photoresist film greater than the second thickness of photoresist film.

18 18. The reticle as in claim 17 in which the first thickness is substantially zero so that
19 an opening is formed in the photoresist film.

20 19. A photolithographic reticle to form a dual damascene profile in a photoresist film
21 having a third thickness, the dual damascene profile having a via at a first thickness of
22 zero and a trench at a second thickness, intermediate between the first and the third
23 thicknesses, from a single exposure to a light source, the reticle comprising:
24

25 a transparent substrate, said substrate passing all incident light to form
26 the first thickness of photoresist profile,

27 a partially transmitting phase shift film, said partially transmitting phase

1 shift film retarding the phase of incident light approximately 180 degrees and
2 intermediately attenuating incident light to form the second thickness in the photoresist
3 profile;
4 an opaque film, said opaque blocking all incident light to form the third
5 thickness in the photoresist profile.

6 20. A reticle as in claim 19 in which said partially transmitting phase shift film
7 transmits more than approximately 20%, but less than approximately 70% of incident
8 light, whereby the reticle, when directed to the light sensitive surface, forms at least
9 three distinct intensities on the illuminated areas of photoresist.
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